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Joseph et al.

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(54) **PHYSICAL TEXTURE DIGITAL DISPLAY SYSTEM**

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CPC .. ***G02B 6/08*** (2013.01); ***G02B 6/06*** (2013.01); ***G02B 6/065*** (2013.01)

(58) **Field of Classification Search**
CPC G02B 6/06; G02B 6/065; G02B 6/08
USPC 385/116
See application file for complete search history.

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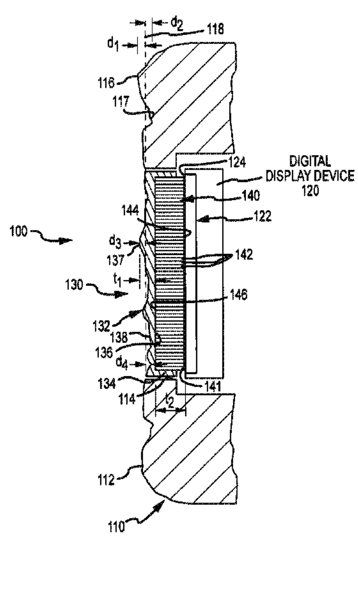
(57) **ABSTRACT**

A display system for displaying images on a textured surface. The system includes a display device with a monitor having a screen operable to output light associated with still or animated images. The system further includes an optical block comprising a plurality of optical fibers bonded together to define parallel guide paths. First ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface. The first block surface is positioned adjacent the screen to receive and transmit the output light along the guide paths to the second block surface. The system includes a textured display element covering the second block surface for receiving light exiting the second block surface and having a non-planar exterior surface emitting or projecting the received light. The textured display element has a body with an optical index matching that of the optical fibers.

34 Claims, 5 Drawing Sheets



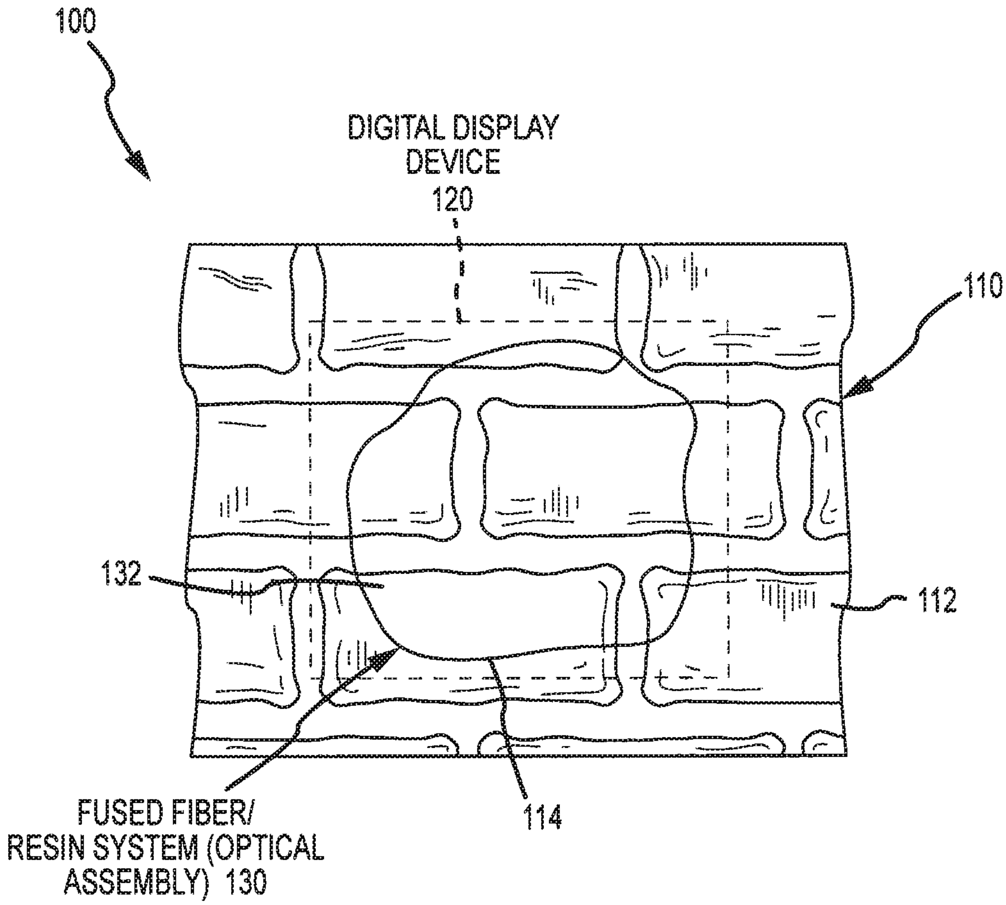

100
DIGITAL DISPLAY
DEVICE
120
110
132
112
114
FUSED FIBER/
RESIN SYSTEM (OPTICAL
ASSEMBLY) 130

FIG.1A

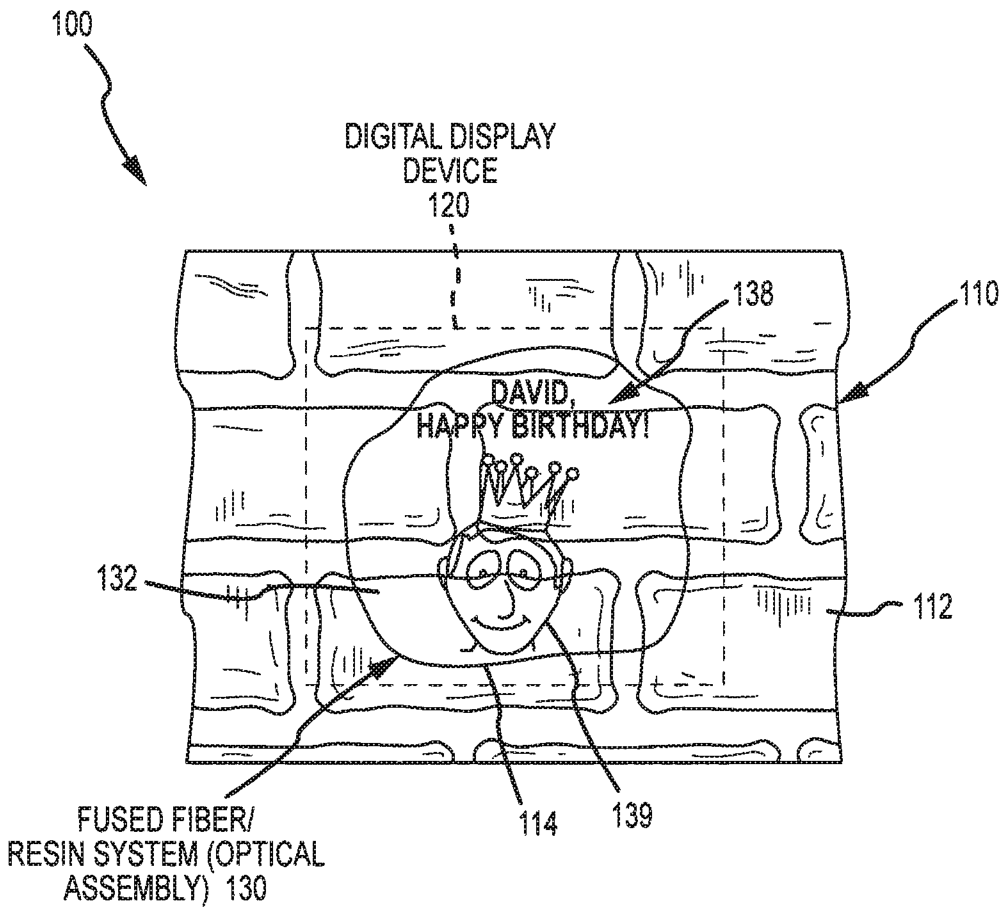

100
DIGITAL DISPLAY
DEVICE
120
138
110
DAVID,
HAPPY BIRTHDAY!
132
112
FUSED FIBER/
RESIN SYSTEM (OPTICAL
ASSEMBLY) 130
114
139

FIG.1B

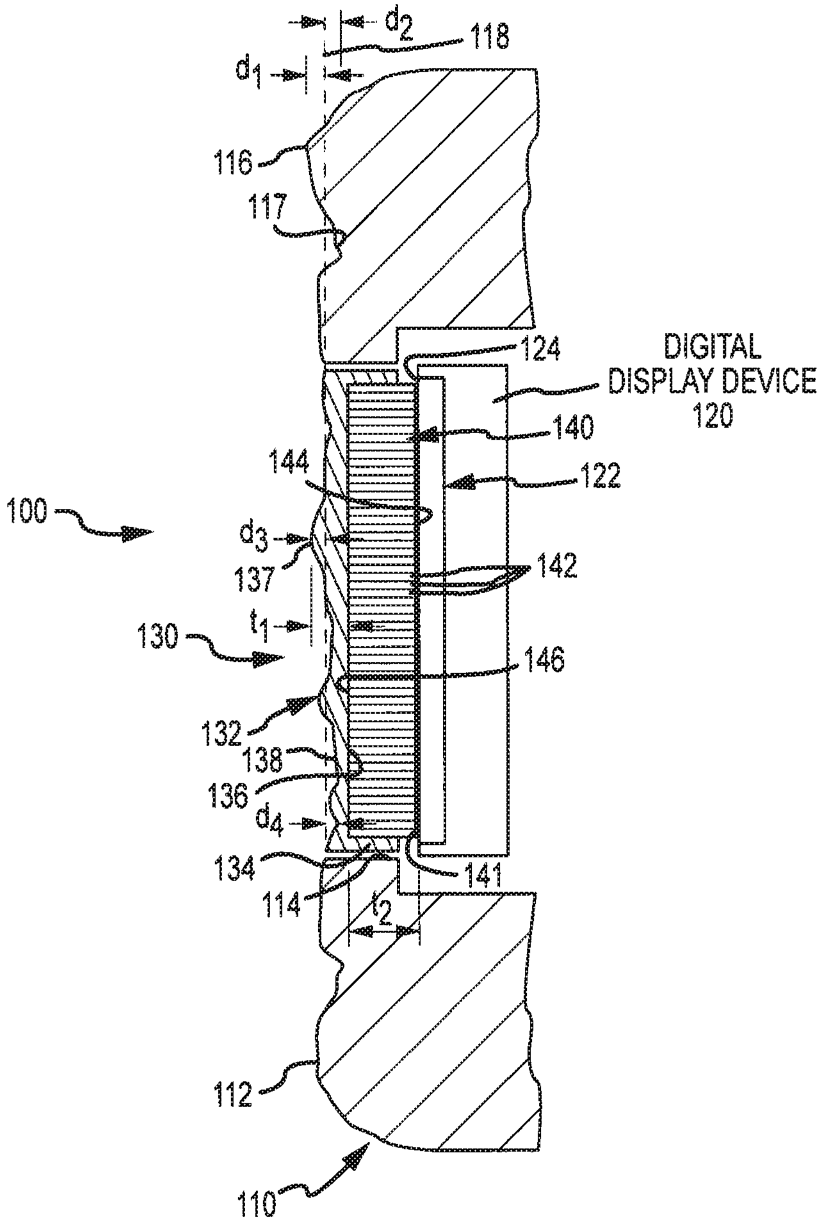
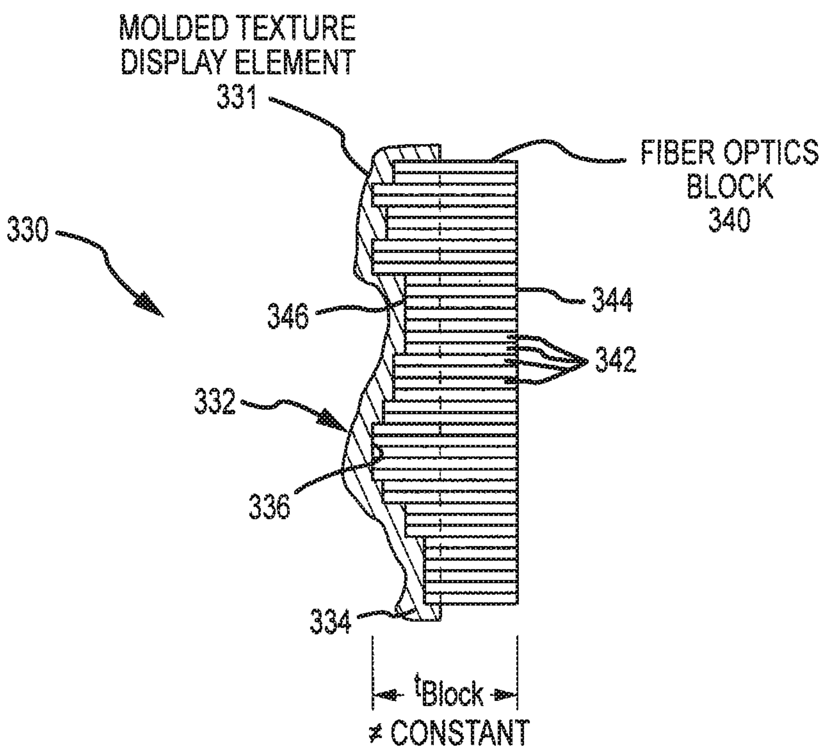

d2
118
d1
116
117
124
DIGITAL
DISPLAY DEVICE
120
140
122
144
100
d3
137
142
t1
130
146
132
138
136
d4
134
141
114
t2
112
110

FIG.2



MOLDED TEXTURE
DISPLAY ELEMENT
331
FIBER OPTICS
BLOCK
340
330
344
346
342
332
336
334
t_{Block}
≠ CONSTANT

FIG.3

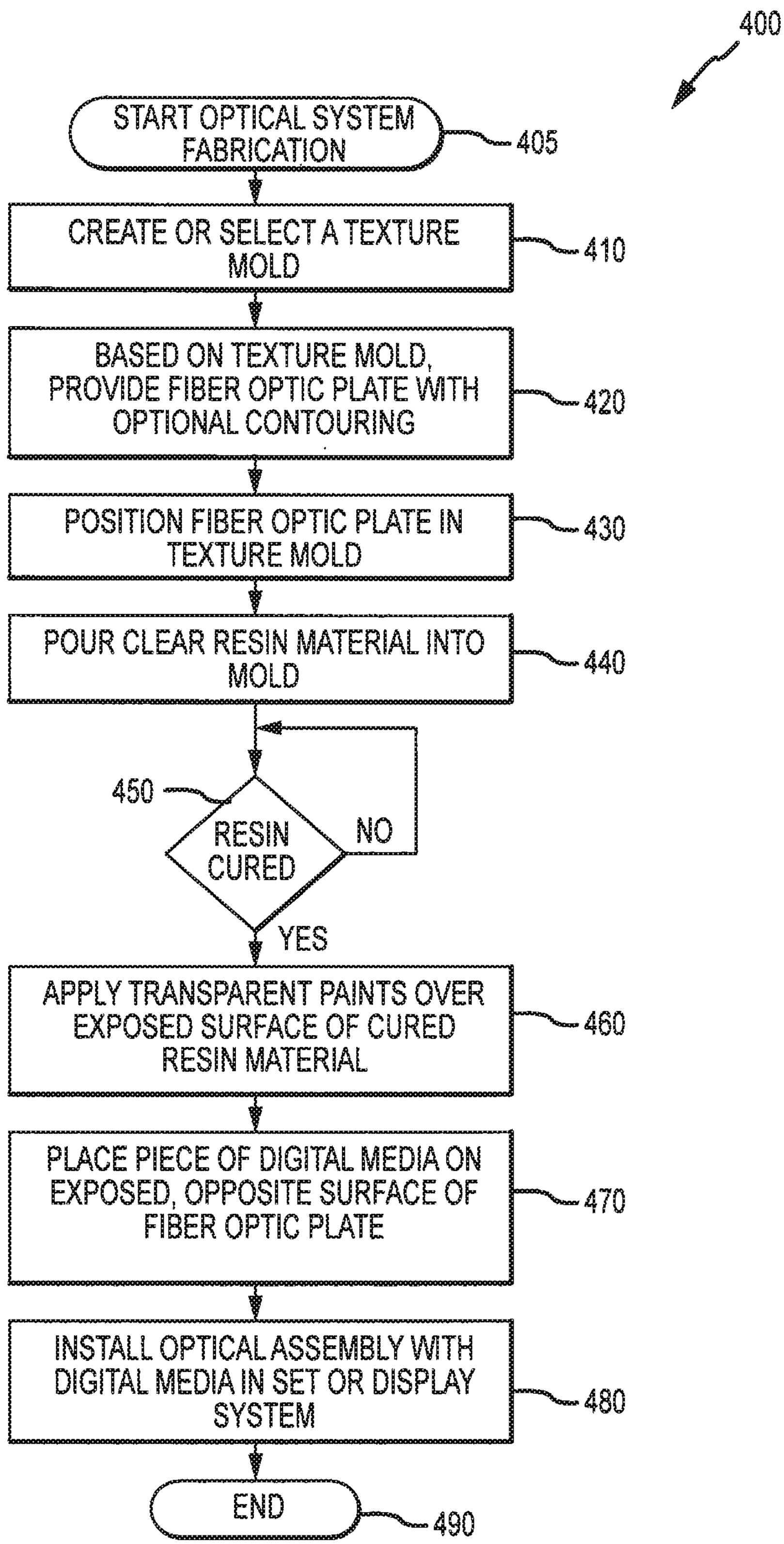

400
START OPTICAL SYSTEM FABRICATION
405
CREATE OR SELECT A TEXTURE MOLD
410
BASED ON TEXTURE MOLD, PROVIDE FIBER OPTIC PLATE WITH OPTIONAL CONTOURING
420
POSITION FIBER OPTIC PLATE IN TEXTURE MOLD
430
POUR CLEAR RESIN MATERIAL INTO MOLD
440
450
RESIN CURED
NO
YES
APPLY TRANSPARENT PAINTS OVER EXPOSED SURFACE OF CURED RESIN MATERIAL
460
PLACE PIECE OF DIGITAL MEDIA ON EXPOSED, OPPOSITE SURFACE OF FIBER OPTIC PLATE
470
INSTALL OPTICAL ASSEMBLY WITH DIGITAL MEDIA IN SET OR DISPLAY SYSTEM
480
END
490

FIG.4

PHYSICAL TEXTURE DIGITAL DISPLAY SYSTEM

BACKGROUND

1. Field of the Description

The present description relates, in general, to methods and systems for displaying imagery upon a textured or non-planar surface such as upon a rock or similar irregular surface, and, more particularly, to methods and systems that use an optical assembly or system to present images or light output from a display device on an offset and textured (or non-planar) image display surface.

2. Relevant Background

There are numerous outdoor and indoor settings where it is desirable to provide imagery on set or decorative features. Generally, the surfaces that are used to display images typically have been kept planar to achieve higher quality and undistorted displays, such as by projecting on a planar wall or screen or through a planar rear projection screen. However, there are many situations where a textured or irregular surface could be and preferably would be used to display images, such as in themed displays where it is desirable to provide images to provide information or to change the look of an object (e.g., use a surface of a rock or brick wall to display a character's image or to display personalized or changing text).

In the past, rear and front projectors have been used to project images on textured or irregular surfaces such as on a concrete or rock wall or through a transmissive object with a textured outer surface. Unfortunately, the use of projectors is problematic in many applications. For example, projectors typically have to be positioned a significant distance apart from the projection surface to provide higher quality images, and there are many settings where these focal distances cannot be accommodated or significant refurbishment or modification of a space or set is required, which can be time consuming and expensive. Also, projectors are maintenance intensive requiring lamp replacements, presenting heating concerns, and requiring mirror set up and adjustment.

There remains a need for a display system that can be used to present images to appear on a textured surface. Preferably, the images could be provided with a digital display device, such as a liquid crystal display (LCD) or the like, so as to not require use of a front or rear projector.

SUMMARY

The present description teaches a display system that is adapted to present images from a display device (e.g., an emissive display such as a digital display device) on an image display surface, which is a non-planar or textured surface. For example, the textured surface may have surface roughness similar to a rock material such as unpolished quartz or may be more irregular with peaks and valleys as found with rocks or similar materials in nature, as found in a brick or other man-made structure, and so on. The display system, thus, allows it to use the content provided to the emissive display device (e.g., an emissive device such an LCD, a light emitting diode (LED)-based display, or other digital or even a non-digital device) to create changing images, color, and animations on a display surface that has a truly physical or three-dimensional (3D) texture.

More particularly, a display system is provided for emitting images from a textured surface while disguising or hiding the presence of the source of such images (e.g., emitting light from what appears to be a rock or brick wall or the like). The system includes a display device with a monitor having a screen operable to output light associated with still or animated images (e.g., images and data content to present a personalized message to a park visitor or to present an advertisement that can be updated periodically).

The system further includes an optical block comprising a plurality of optical fibers bonded together to define parallel guide paths. First ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface. The first block surface is positioned adjacent the screen to receive and transmit the output light along the guide paths to the second block surface. The system also includes a textured display element covering the second block surface with an interior surface, which receives the output light exiting the second block surface and a non-planar exterior surface opposite the interior surface emitting the output light received at the interior surface.

In some implementations, the textured display element has a body formed of a substantially transparent material with an optical index matching an optical index (i.e., index of refraction) of the optical fibers in the block. The body may be formed by positioning the block within a mold within surfaces defining the exterior surface of the textured display element, pouring a volume of liquid resin between the mold and the second surface of the block, and curing the resin such that the material of the body is bonded to the second surface without air gaps or spacing. The body may be formed such that it is relatively thin such as with a maximum thickness of 1 millimeter to limit distortion or other negative optical effects between a viewer and the second ends of the optical fibers.

The textured display element may also include a layer of transparent paint covering at least portions of the non-planar exterior surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface. In these and other cases, the first and second block surfaces may be planar. In some implementations, though, the first block surface is planar and placed in abutting contact with the screen of the monitor of the display device while the optical fibers of the blocks are provided with two or more lengths such that the second block surface is non-planar (or textured or contoured). In such implementations, the textured display element may include a layer of transparent paint applied to the second block surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface While concurrently being at least translucent to the output light received at the interior surface. The first block surface typically will be optically bonded to the screen of the monitor of the display device.

In the display system, the display device may be a digital display (such as an LCD, an LED-based display, or the like) emitting the output light from pixels of the screen. In these systems, the optical fibers preferably each have a diameter having a magnitude less than a maximum size of the pixels of the screen. The display system may also include a support or set element with an exterior surface and with a hole that extends through such a surface for receiving the textured display element and at least a portion of the block. In these display systems, the exterior surface of the support element can have a texture, and the non-planar exterior surface of the textured display element may have a texture matching the texture of the exterior surface of the support element. Transparent paint with coloring similar to the support element's exterior surface can be applied to hide the transparent body of the textured display element (and components behind it in the display system) and to blend the textured display element in with the surrounding materials of the support element.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates a display system with an optical assembly with a textured display element combined with a fused fiber plate or block according to the present description operating in a first state (e.g., with a display device off or not operated to display an image);

FIG. **1**B illustrates the display system of FIG. **1**A operating in a second state (e.g., with the display device on and operating to display an image made up of first portion providing text and a second portion providing a still or an animated character or other image(s));

FIG. **2** is a side or end view of the display system of FIGS. **1**A and **1**B with a portion of a textured support or set element cut away to expose components of the optical assembly and the display device and a portion of the textured display element cut away to expose the fused fiber block;

FIG. **3** is side or end view, similar to that of FIG. **2**, of an optical assembly in which a plate or block formed of optical fibers has one of its surfaces machined to provide a textured surface over which a textured display element may be applied; and

FIG. **4** is a flow chart of an exemplary process for fabricating a display system of the present description including forming an optical assembly.

DETAILED DESCRIPTION

The present description is directed toward methods and systems that use a plate or block formed of fused optical fibers ("fused fiber plates or blocks") to translate an output light or image from a first surface on digital display device or other display to a second surface, which may be planar or irregular/textured. The fused fiber plate or block may be inserted into or, in some cases, molded to a textured display element, and ends of the fibers in the plate/block may abut or be positioned proximate to an inner surface of the textured display element. In other words, the offset second surface to which the image is translated or presented by the optical fibers may be the inner side of the textured display element.

The textured display element may be formed of a transmissive material such as plastic, glass, ceramic, or the like, and its exterior surface ("image display surface" in this case) may be textured or non-planar. The exterior surface may further be coated or painted with a layer of material that causes it to be opaque (or substantially so) to light striking the exterior surface while it is transmissive to light from the optical fibers of the plate or block (e.g., transmissive when backlit). In other embodiments, the outer layer of material (transparent paint or the like) may be applied directly to the ends of the optical fibers of the plate/block.

The plate/block may be imbedded in the textured display element by positioning the plate/block within a mold with interior surfaces textured and shaped to define the exterior surface of the textured display element. A clear or transmissive material such as a plastic resin may be poured into the mold such that the ends of the fibers of the plate/block are molded to or mated with the interior surface of the textured display element with no air space. In some cases, the interior surface of the textured display element is planar, and the projection surface defined by the ends of the fibers of the plate/block is also planar (and sometimes polished and/or glossy to enhance the output display).

In other cases, though, the interior surface of the textured display element is contoured or textured similar to the exterior surface (e.g., the layer of transmissive material (or body of the element) defines a relatively constant offset such as 0.5 to 2 or more millimeters or the like). In such cases, the projection surface defined by the ends of the fibers of the plate/block are machined (e.g., cut or routed) to have a contour or texture matching (or similar to) the interior surface to provide contact with the second (or interior) surface or to at least limit (or even minimize) any air gap between the optical fibers and the body of the textured display element. The machining or routing of the fused fiber plate/block may be based on a scan of the surface texture (e.g., a relatively deep or varying texture such as one with depths of 1 to 5 mm or more from "peak" or high points of the projection surface). The physical texture of the textured display element enhances the believability of the display (e.g., the textured surface is the source of the image and hides the digital display device) and can even be touched by viewers in many implementations. Nearly any textured or contoured surface may be used such as those that can be created by a molding process, and the fabrication of the textured display element and fused fiber plate/block may leverage existing texture stamping techniques and sculpting techniques.

Together, the textured display element and the fused fiber plate/block can be thought of as providing a single optical system for translating a display output (image and/or light) from a first surface (e.g., exterior surface of a monitor) to a second surface offset some distance, and this second surface is typically non-planar (or textured or contoured). The optical system or assembly may be used with a standard digital display device such as an LCD, OLED, or the like, and the output surface of the display device is placed against or near to a first or receiving end of the fibers of the plate/block (which may be planar and/or polished (to be glossy)).

By using a digital display device, the display system can take advantage of the latest LCD/LED and other technologies. Digital display devices are much slimmer than projectors in most cases and can fit into most display environments more readily than rear or front projectors. Digital display devices have long lives and typically have much better color and contrast to give better images when compared with many projectors. Further, digital display devices generate less heat than projectors and are often less expensive and are easier to purchase, maintain, and replace. The use of fiber optics to translate the output image to a second surface (e.g., the exterior surface of the textured display element) is desirable, in part, because the image has minimal degradation such that the display system operates to provide a crisp and relatively sharp image.

FIGS. **1**A and **1**B illustrate a display system **100** of the present description that is operating in a first state and a second state, respectively. Particularly, in the first state shown in FIG. **1**A, a digital display device **120** is "off" or operated to be dark and not display images (or light, colors, and so on). In the second state shown in FIG. **1**B, the digital display device **120** is "on" or operated to display images as shown at **138** (with text or information being displayed that can be used to personalize the display system **100** to a viewer) and at **139** (with an image (still or animate) of a character or other object such as an image of the viewer or his favorite character in themed attire or celebrating a birthday or special event).

The light output from the digital display **120** is transmitted through an optical assembly or system **130** to be displayed, viewed, or visible to a viewer of the display system **100** as shown at **138**, **139** on or via a textured or contoured exterior surface **132** of a textured display element of the assembly **130**.

The light output from the digital display **120** is translated to this surface **132**, which is offset a distance (e.g., 1 to many millimeters) from a monitor or output surface of the display device **120**, by a fused fiber block of the optical assembly **130** as discussed below at least with reference to FIG. **2**.

The display system **100** includes a support or set element **110** that is adapted in this example for structurally or physically supporting the optical assembly **130**. Particularly, the support element **110** has a hole or portal **114** for receiving the optical assembly **130** and allowing the exterior textured surface **132** of the optical assembly to be exposed to a viewer and, typically, to be positioned adjacent to and, typically, substantially at the same level as the support element exterior surface **112**. The support element **110** may be fabricated so that the exterior surface **112** is non-planar or is textured/contoured. For example, the support element **110** may be formed of rock, stone, tile, concrete, brick, plastic, or the like assembled into a wall or be formed of materials (e.g., plastics, ceramics, or the like) to replicate such a wall or structural feature. The support element **110**, as a result, has rough surface **112** that has raised and recessed portions (e.g., is non-planar), and the support element **110** is typically opaque or at least not transparent. In this way, the support element **110** may receive the display element **120** and hide its existence from the viewer's sight shown by using dashed lines in FIGS. **1**A and **1**B to show the presence of the display element **120** behind the front or exterior surface **112**.

To further disguise the presence of the display element **120**, the optical assembly **130** is positioned within the portal or hole **114** in support element **110**, and the textured exterior surface **132** of the textured display element is fabricated to have an appearance similar to that of the surrounding and adjacent exterior surface **112** even though it may be formed of a dissimilar material. Particularly, the surface **132** is textured or contoured in a manner that matches or is at least similar to that of the exterior surface **112**. Further, the surface **132** may be provided by coating or applying a transparent resin body of the textured display element with a layer (or coat(s)) of transparent paint or similar material that is opaque or nearly so to exterior or environmental lighting striking the surfaces **132** but that is translucent to transparent when the optical assembly **130** is backlit by the display device **120**. In this manner, the surface **132** blends in with the surround material of support element surface **112**.

This effect is shown in FIGS. **1**A and **1**B in which the display system **100** is first operated with the display device **120** off or not showing images (not outputting light visible through the layer of material on surface **132**) and then is second operated with the display device on or showing images **138**, **139**. The optical assembly **130** is configured to translate the output light of the display device **120** to the surface **132**, and the shape (e.g., the shape of the outer periphery) of the fused fiber block (discussed with reference to FIG. **2** below) defines which portion or area of the monitor or output surface of the display device **120** is transmitted to the surface **132** (shown as an irregular circular shape in this example but nearly any shape may be used for the fiber fused block). Further, the content provided via the display device **120** may be masked so that light is only presented via portions of the optical assembly **130** such as the text/data portion **138** and the still or animated object portion or image **139**. With the use of the display system **100**, the true source (display device **120**) of the imagery **138** and **139** is hidden, and the imagery **138** and **139** appears to be emitted from the textured surface **132**.

FIG. **2** is a side or end view of the display system **100** of FIGS. **1**A and **1**B with a portion of a textured support or set element **110** cut away to expose components of the optical assembly **130** and the display device **120** and further with a portion of the textured display element cut away to expose a fused fiber block **140** of the optical assembly **130**. The textured display element has a body **134** with a recessed surface **136** for receiving the fused fiber block or plate **140**, and the body **134** extends over and about the fused fiber block **140**. Opposite the recessed surface **136** on the body **134** of the textured display element is the textured exterior surface **132**, which is shown with dashed line **118** to be in the same "plane" or about the same level as the exterior surface **112** of the support element **110** when the optical assembly **130** is inserted into the hole/portal **114** of the support element **110**.

The body **134** may be formed of a transparent material such as a plastic, glass, or ceramic that is chosen to have the same optical index as the optical fibers **142** of the block **140** or to be within a range about this optical index (i.e., use a matching optical index to choose materials for the textured display element). In this way, the diffraction or other optical effects when light is passed from the block **140** to the body **134** are minimized or limited. Further, as shown in FIG. **2**, recessed surface **136** is abutting (or nearly so) so as to avoid (or limit) an air gap between the block **140** and the textured display element, again to maintain the quality of the image/light transmitted from the display device **120** to the body **134** via the optical block **140**.

As shown, the support element **110** has an exterior surface **112** that is contoured or textured such that it is non-planar. In this context, "non-planar" is meant to refer to a surface that has raised and/or recessed surfaces relative to a plane passing through a substantial portion of a surface or edge of an object. For example, a plane **118** is shown to extend generally through or along the exterior surface **112**. However, the surface **112** is non-planar (i.e., textured or contoured) as there are one or more raised peaks or surfaces **116** that extend upward or outward from the plane **118** a distance, d_1 and also (in this non-limiting example) includes one or more recessed valleys or surfaces **117** that extend downward or inward from the plane **118** a distance, d_1. Distances, d_1 and d_2, may be the same or differ and typically have a value of 0.1 or more millimeters. Likewise, the exterior surface **132** of the textured display element of the optical assembly **130** is considered textured or non-planar because it includes raised surfaces/peaks **137** extending from the plane **118** a distance, d_3, and recessed surfaces/valleys **138** extending from the plane **118** a distance, d_4, in the opposite direction (which may be 0.1 to 3 or more millimeters).

The amount of texturing of the surface **132** may be selected to generally match that of the surface **112** such that the textured display element may appear to be formed of the same material as the support element **110** (e.g., not obvious that the body **134** is in the portal/hole **114** in element **110**). To provide abutting contact and/or an optical connection with the fused fiber block **140**, the body **134** may be formed of a clear material (such as a plastic resin) poured into a mold containing the block **140** (as discussed below). The surface **132**, as discussed above, may be painted to have an appearance similar to that of exterior surface **112**, e.g., to blend and match transition between materials of body **134** and support element **110**. The paint or coating material provided on surface **132** may be chosen so as to be opaque from outer light but to allow the body **134** and surface **132** to be transmissive when backlit (e.g., when light from block **140** is directed onto the recessed surface **136** of the body **134** of the textured display element). For example, a transparent paint finish may be used for the surface **132**, e.g., transparent paint or stain available from AquaTec Coatings and other distributors. The selectively transmissive surface may be provided with a light "dusting" of nearly any paint, but, in these cases, it may be useful to feather even this dusting of paint in with surrounded paint surface to blend in both off and on states. This can be challenging as it is often highly dependent upon the skill of the painter.

The display system **100** includes a digital display device **120**, and this may take many forms to implement the system **100**. For example, the display device **120** may be an off-the-shelf digital display or emissive display such as an LCD, an LED display, or the like. The display device **120** includes a monitor or screen **122** that is used to output image/light via a plurality of pixels, and the monitor/screen **122** has a planar (typically glass or plastic) output surface **124** that is positioned to face the optical assembly **130**. In this manner, when the digital display device **120** is operated to output images, the associated light it outputs is emitted toward the optical assembly **130**.

Significantly, the display system **100** includes the optical assembly **130**, and the optical assembly **130** is configured to translate the light emitted from the monitor/screen surface **124** (a first surface) to the textured surface **132** (a second surface offset some predefined distance) with little or acceptable degradation in optical quality of the images provided by the emitted light from display device **120**. To this end, the optical assembly **130** includes a block or plate **140** formed from a plurality (hundreds or thousands) of optical fibers **142**. The optical fibers **142** are bound or fused together and are arranged to extend in a single direction or to have their longitudinal axes parallel so as to define numerous side-by-side and parallel light transfer paths. The material (such as plastic, glass, or the like) used for the fibers **142** may vary, but, as noted above, it is preferable for the material of the body **134** of the textured display element to be chosen to have an optical index (or index of refraction) that matches that of the fibers **142** (such as about 1.5 to 1.7 with 1.62 being common for some optical fibers). In general, "optical fiber" refers to a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair, and it can function as a waveguide, or "light pipe" to transmit light between the two ends of the fiber.

The block or plate **140** includes a first surface **144** that is proximate to the monitor/screen surface **124** and a second surface **146** opposite the second surface **144**. The first and second surfaces **144** and **146** are made up of the tips or ends of the many fused fibers **142**, such that light from the monitor/screen element **122** may enter the block **140** via surface **144** and exit out surface **146** after being guided in parallel paths by the optical fibers **142**. The surfaces **144** and **146** may be polished and/or glossy to enhance optical coupling with the surfaces **124** and **136** (or at least surface **124** of the monitor/screen **122**).

To further enhance optical coupling between the block **140** and the display device **120**, the first surface **144** of the fused fiber block **140** may be placed in contact with the surface **124** with this abutting position retained such as in a mechanical or structural manner (e.g., with clamps or the like adjoining the optical assembly **130** to the display device **120**). In other implementations or additionally, the block surface **144** is optically bonded to the planar surface **124** of the display device **120**. This may be achieved as shown with a layer **141** of an optically clear adhesive film (such as optical bonding adhesive distributed by **3**M and other distributers or manufacturers) or a layer of glue or epoxy suited for optical bonding of two components.

In the illustrated embodiment, the recessed surface **136** and the output surface **124** of the monitor/screen **122** are both planar and parallel to each other. Hence, the block **140** is formed of equal length fibers **142** that define the thickness, t_2, of the block **140**, which may be 0.25 to 1 inch or more. The fibers **142** act to translate light from surface **124** to the recessed surface **136**, and the fibers **142** are fused or bonded together to form what appears to be a solid block of glass or plastic. The diameter of the fibers **142** may vary to practice the system **100**, but, preferably, the display system **100** will be more optically effective when the fibers have smaller diameters because the tighter the pitch the greater the resolution provided by the optical fiber block **140** and because there will then be little or no air spaces in block **140**. In some implementations, the fibers **142** are chosen specifically to have diameters that are smaller than the diameters or sizes of the pixels of the screen/monitor **122**. In this way, the fused fiber block **140** provides physical pixels that optically offset an image from one layer to another layer (e.g., from output surface **124** of monitor/screen **122** to recessed surface **136** of the textured display element).

The body **134** is then used to provide a textured surface **132** between the second surface **146** of the block **140** and a viewer. Again, the body **134** is formed of a transparent material, but the textured surface **132** is painted or coated with a material that is opaque until it is backlit by light output from the fibers **142** of the optical fiber block **140**. In some settings, it is desirable for the image output from the surface **146** of the block **140** to be relatively close to a viewer as practical while still providing a desired amount of texturing or contouring with surface **132**. In other words, the image has a better quality or less optical losses if the surface **146** provided by ends of fibers **142** is exposed or nearly so to a viewer. With this in mind, the portion of the body **134** that is positioned over the surface **146** of the block **140** (portion covering the block **140**) is fabricated to have a relatively small thickness, t_1, such as less than about 1 millimeter (e.g., 0.25 to 0.75 mm or the like) as this provides enough material to match roughness or texturing of surrounding materials and surface **112** while not requiring light from fibers **142** to travel a large distance without the guidance of the fibers **142** (or physical pixels useful for offsetting the image of display device **120** a distance while retaining locations of pixels/light from screen/monitor **122**).

In some embodiments, it may be desirable to provide a uniform thickness, t_1, of material between the optical block and the textured surface exposed to the viewer. For example, the thickness, t_1, in the optical system **130** of FIG. **2** will vary across the second surface **146** of the block **140** as varying thickness of the material of the body **134** of the textured display element is used to provide texture or a non-planar quality for surface **132**. But, this may lead to some distortion and/or may not meet the desire for a particular display system to place the second surface **146** and ends of the fibers **142** as close as possible to the viewer.

With the goal of minimizing this separation distance (or thickness, t_1), FIG. **3** illustrates another embodiment of an optical assembly **330** that may be used in a display system of the present description (such as system **100** of FIGS. **1**A to **2**). The optical assembly **330** includes a block **340** made up of a plurality of optical fibers **342**, which may be bonded or fused tightly together in a parallel manner. The block **340** has a first side or surface **344** that is polished or glossy and planar, and the first surface **344** would be optically coupled to a planar surface of a monitor or screen of display device such as an LCD or the like. The fibers **342** act to guide the output light from each of the pixels of such a display device to an offset location associated with the second end of each of the fibers **342**.

In contrast to optical block **140**, the optical block **340** is fabricated so as to have a contoured or textured second surface (or projection/light-emitting surface) **346** rather than a planar surface. In other words, the fibers **342** do not have equal lengths and typically the fibers **342** will have 2 to 10 or many more different lengths to provide a texture that is matched to a surround material of a display assembly in which the optical assembly **330** is to be used. This results in the thickness, t_{Block}, of the block **340** varying across the second surface **346**. The varying thickness, t_{Block}, may be achieved by first forming the optical block **340** with fibers of equal length being fused together, and, then, this block may be machined (e.g., with a router or other tool) to cut away varying lengths or segments of the fibers to provide the fibers **342** shown with a plurality of lengths (and a block **340** of varying thickness, t_{Block}).

The optical assembly **330** further includes a textured display element **331** that covers the textured or second surface **346** of the block **340**. The textured display element **331** has a body (or a layer of material) **334** that is preferably opaque to exterior light but transmissive (e.g., translucent to transparent with more transparent being preferred in many optical assemblies **330**) when backlit by light passing through the fibers **342** of the block **340**. The body **334** is shown to have a uniform thickness (or a substantially uniform thickness) that may be less than 1 millimeter such as 0.1 to 0.5 millimeters or the like.

In some cases, the body **334** is provided by applying a coating or layer of transparent paint that is opaque to light striking the exterior, textured surface **332** but transparent to light striking an interior surface **336** (light emitted from block surface **346**). In other cases, though, the body **334** of the textured display element **331** is provided by molding a volume of a clear resin such as a plastic resin over the machined/cut block **340**. In still other cases, the body **334** is formed first, and the surface **346** is machined based on the contours of the interior surface **336**, e.g., perform scan of surface **332**, apply desired offset for thickness of material of body **334**, and then cut (such as with a computer numerical control (CNC) router or the like) fibers **342** to form the textured, second surface **346** of the optical block **340**.

As discussed above, the material used for the body **334** may be chosen such that the textured display element **331** has an optical index that matches that of the fibers **342** of the block **340**. Such texturing of the projection surface of the optical block while using a thin layer of resin and/or transparent paint allows the optical assembly to be used provide a greater amount of offsetting without undesirable losses (as may be the case if the texturing were significantly larger in the optical assembly **130** of FIG. **3** in the body **134**). The addition of a resin or other layer may be useful, though, to achieve a wider variety of appearances and textures. Filling and further shaping, in addition to the machining/router cutting, may be performed to achieve desired final shapes of the surface **132** (e.g., use a clear resin to achieve a desired look and feel).

The optical assemblies described herein, including assembly **130** and **330**, may be fabricated using a variety of processes and techniques. For example, a plate or block of fused optical fibers may be a obtained (fabricated or purchased as an off-the-shelf or special order to have a desired thickness and perimeter shape) with first and second surfaces that are parallel and polished/glossy (e.g., the block **140** shown in FIG. **2**). Then, this optical block of fibers may be positioned in a mold and a resin or epoxy for a textured display element may be poured into the space between the second surface of the block and the interior surfaces of the mold (with the first surface of the block covered or otherwise blocked off from the resin/epoxy flow). The material is chosen to have an optical index that is the same as or matches the fibers of the block, and, as a result, the textured display element will be clear/transparent (or nearly so). The inner surfaces of the mold define the exterior, non-planar surface of the textured display element and the amount and type of texture, which is selected to match or be the same/similar to that of exterior surfaces of a support or set element that will receive and support the optical assembly.

A layer of a material (e.g., a transparent paint or the like) is then applied that is opaque to exterior light striking the exterior surface but is transmissive when backlit via the optical fiber block, and the material may be selected to have the same or a matching color as that of the surfaces of the nearby and surrounding material/surface of the support or set element. Casting or molding the textured display element is sometimes desirable as it can be used to obtain a very clear layer of material for defining the textured exterior surface for the optical assembly while avoiding (or limiting) an air gap between the interior or recessed surfaces of the textured display element and the second or projection surface of the fused fiber block. In this way, the fused fiber block, the layer of clear material of the textured display element, and the transparent paint layer act together as a single optical system (e.g., one with relatively small distortion at transitions due to elimination of spaces and one with materials of similar optical qualities including matching optical indexes).

FIG. **4** illustrates a method **400** of fabricating an optical system that can then be used in presenting a display to a viewer in which the source of an image or displayed content is hidden or disguised. The method **400** starts at **405** such as with identifying a location where it is desired to present imagery on a textured or non-planar surface. For example, an amusement park may include walls leading into a ride that are fabricated with rough surfaces such as to be formed of concrete, stone, brick, or the like or at least to have contoured outer surfaces. It may be useful to selectively cause images to be displayed on this non-planar, textured surface. To this end, a hole or portal may be created in a wall to receive an optical assembly of the present description. In other cases, a play or other entertainment set may have one or more contoured or non-planar surfaces where it is desirable to provide visual content, which can readily be updated and changed over time, and a location may be identified in this set for supporting an optical assembly of the present description.

At **410**, the method **400** continues with creating or selecting a textured mold. The mold has interior surfaces that match a desired depth and peripheral shape of an optical assembly, and, more significantly, the interior surface of the mold also define a texture or roughness that will be provided on an exterior or textured display surface of the optical assembly. This mold may be fabricated or may be chosen from a number of available texture molds.

With this mold selected, a plate or block formed of optical fibers (as discussed above) may be provided (e.g., fabricated or purchased from commercial providers of such blocks) at **420**. The fiber optic plate or block may be cut to have a particular external shape such as a rectangular shape, a circular shape, or the like to suit a portal/hole in a set or support element or to have a size and shape similar to that of the screen/monitor of a digital display device (e.g., to cover all or a subset of the area of the output surface of such a screen/monitor as shown in FIGS. **1A** to **2**). Further, one of the surfaces of the optical fiber block (e.g., the surface to be used as the projection or "second" surface as discussed above) may be machined such as with a CNC router to have a desired texture or non-planar shape (e.g., with fibers of two or more lengths rather than a uniform fiber length or block thickness).

At step **430**, the method **400** continues with positioning the fiber optic plate within the recessed volume or space of the texture mold. Step **430** may involve rigging or supporting the fiber optic plate so that one of its surfaces (e.g., the contoured (or planar) projection surface) is proximate to the interior surfaces of the mold. For example, the projection surface of the fiber optic plate may be supported at an offset distance matching the planned thickness of the body of the textured display element away from the portion of the texture mold defining the exterior surface of this textured display element of the optical assembly. Careful attention may be given to this positioning to allow material to fill in over the projection surface of the fiber optic plate, and, in some cases, the mold is configured such that when the plate is properly positioned in the mold the interior or first surface of the plate (the surface to be optically bonded to the display device screen/monitor) is flush with edges of the mold or fill level of the mold (e.g., to have resin cover all of the sides of the fiber optic plate).

The method **400** continues then at **440** with a volume of clear resin material being poured into the mold to fill in around the fiber optic plate. The resin is allowed to cure in the method **400**, and, at **450**, the method **400** involves allowing the mold to sit until the resin is cured. If not, the method **400** continues at **450**. The particular resin used may vary to practice the method **400**, but, as discussed above, it may be desirable that the resin be chosen to produce, once cured, a solid material that is transparent (or substantially so) and with an optical index that matches that of the optical fibers of the plate (or within a predefined tolerance of such a value). In one embodiment, the inventors have found it useful to use FOCI Crystal Clear UV table top epoxy resin, but this is just one useful example of the types of resin that may be used in the pour step **440**.

Once cured, the method continues at **460** with applying transparent paints over the exposed surface of the cured resin material (the material forming the body of the textured display element and providing the textured exterior surface of the optical assembly). The paints (or other covering materials) are selected to be opaque or nearly so and to have an appearance when dry similar to the material that will surround the textured surface once the optical assembly is installed for use (e.g., to be gray when adjacent slate, to be red when adjacent red brick, and so on). The painting **450** may involve feathering in the areas where the images from the display device are to be presented such that the resin remains more transparent when backlit in these areas. In areas outside or not over the fiber optic plate, standard paints may be used or blended in because transmission of light is not required for these areas of the textured display element. As with resin, the specific paint used may vary to practice the method **400**. However, in one exemplary implementation of the method **400**, the inventors used transparent glass paint available from Americana Crystal Gloss Enamels, with an optional top coat of varnish such as Golden Archival Varnish or the like.

At step **470**, a piece of digital media such as an LCD may be placed against the exposed and planar surface of the fiber optic plate, and the two surfaces may be optically bonded using an adhesive or other optical joining material. The placing of the media at **470** may involve careful alignment of the surface of the monitor/screen with portions of the fiber optic plate such that locations of images displayed on the screen/monitor correspond with desired portions/areas of the fiber optic plate and, therefore, with areas of the exterior, textured surface opposite the digital media.

The optical assembly may then be installed at **480** within a set or display system, such as with the optical assembly extending through a hole or portal in a support element or wall to have the textured surface matching the location (or level/height) of the textured, non-planar surfaces of the surrounding materials. The method **400** may then end at **490**, and the display system with the fabricated optical assembly may be operated to selectively present images (animated characters, text, still objects, and other content that may change over time) that appear to originate on or from the textured exterior surface of the optical assembly rather than from the true source (i.e., the placed piece of media such as an LCD or the like).

Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

We claim:

1. A display system, comprising:

a display device with a monitor having a screen operable to output light associated with still or animated images;

a block comprising a plurality of optical fibers bonded together to define parallel guide paths, wherein first ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface and wherein the first block surface is positioned adjacent the screen to receive and transmit the output light along the guide paths to the second block surface; and

a textured display element covering the second block surface with an interior surface receiving the output light exiting the second block surface and a non-planar exterior surface opposite the interior surface emitting the output light received at the interior surface,

wherein the textured display element has a body formed of a substantially transparent material with an index of refraction matching an index of refraction of the optical fibers in the block.

2. The system of claim **1**, wherein the body has a maximum thickness of **1** millimeter and wherein the interior surface is bonded to the second surface of the block without air gaps.

3. The system of claim **1**, wherein the textured display element further comprises a layer of transparent paint covering at least portions of the non-planar exterior surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface.

4. The system of claim **1**, wherein the first and second block surfaces are planar and wherein the first block surface is optically bonded to the screen of the monitor of the display device.

5. The system of claim **1**, wherein the first block surface is planar and placed in abutting contact with the screen of the monitor of the display device and wherein the optical fibers of the blocks are provided with two or more lengths whereby the second block surface is non-planar.

6. The system of claim **5**, wherein the textured display element comprises a layer of transparent paint applied to the second block surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface.

7. The system of claim **1**, wherein the display device comprises a digital display emitting the output light from pixels of the screen and wherein the optical fibers each have a diameter having a magnitude less than a maximum size of the pixels of the screen.

8. The system of claim **1**, further comprising a support element with an exterior surface and with a hole for receiving the textured display element and at least a portion of the block, wherein the exterior surface has a texture and wherein the non-planar exterior surface has a texture matching the texture of the exterior surface of the support element.

9. An optical assembly for use with a digital display device with a planar monitor screen, comprising:

a block of optical fibers, wherein first ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface, wherein the first block surface is planar for mating with the planar monitor screen; and

a textured display element comprising a layer of material covering at least the second block surface of the block with an interior surface adjacent the second block surface and exterior surface facing away from the block,

wherein the exterior surface is textured and wherein the material of the layer is substantially transparent to light, and

wherein the textured display element further comprises a layer of transparent paint covering at least portions of the textured exterior surface, whereby the textured display element is substantially opaque to light striking the textured exterior surface and is transmissive of light striking the interior surface.

10. The assembly of claim **9**, wherein the second block surface is non-planar.

11. The assembly of claim **9**, wherein the material of the layer in the textured display element has an index of refraction matching an index of refraction of the optical fibers.

12. The assembly of claim **9**, wherein the layer of the material has a thickness less than about 1 millimeter.

13. The assembly of claim **9**, wherein the interior surface of the layer of material is mated to the second surface of the block without air gaps therebetween.

14. A method for fabricating an optical assembly, comprising:

positioning a fiber optic plate within a mold with a surface of the fiber optic plate offset a distance from a mold surface defining a texture for an exterior surface of a textured display element;

pouring a volume of resin into the mold to at least partially fill a void between the fiber optic plate surface and the mold surface; and

curing the resin to form a body of the textured display element, wherein the body is at least translucent to light.

15. The method of claim **14**, wherein the body and fibers of the fiber optic plate have matching indices of refraction.

16. The method of claim **14**, further comprising applying at least one coat of transparent paint to the exterior surface of the textured display element after the curing step.

17. The method of claim **14**, further comprising machining the surface of the fiber optic plate prior to the positioning step such that the surface of the fiber optic plate is non-planar.

18. The method of claim **14**, further comprising placing a digital media element against an exposed surface of the fiber optic plate opposite the surface of the fiber optic plate upon which the body of the textured display element is attached.

19. A display system, comprising:

a display device with a monitor having a screen operable to output light associated with still or animated images;

a block comprising a plurality of optical fibers bonded together to define parallel guide paths, wherein first ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface and wherein the first block surface is positioned adjacent the screen to receive and transmit the output light along the guide paths to the second block surface; and

a textured display element covering the second block surface with an interior surface receiving the output light exiting the second block surface and a non-planar exterior surface opposite the interior surface emitting the output light received at the interior surface,

wherein the first block surface is planar and placed in abutting contact with the screen of the monitor of the display device and wherein the optical fibers of the blocks are provided with two or more lengths whereby the second block surface is non-planar, and

wherein the textured display element comprises a layer of transparent paint applied to the second block surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface.

20. The system of claim **19**, wherein the textured display element has a body formed of a substantially transparent material with an index of refraction matching an index of refraction of the optical fibers in the block and wherein the body has a maximum thickness of 1millimeter and wherein the interior surface is bonded to the second surface of the block without air gaps.

21. The system of claim **19**, wherein the textured display element has a body formed of a substantially transparent material with an index of refraction matching an index of refraction of the optical fibers in the block and wherein the textured display element further comprises a layer of transparent paint covering at least portions of the non-planar exterior surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface.

22. The system of claim **19**, wherein the first and second block surfaces are planar and wherein the first block surface is optically bonded to the screen of the monitor of the display device.

23. The system of claim **19**, wherein the display device comprises a digital display emitting the output light from pixels of the screen and wherein the optical fibers each have a diameter having a magnitude less than a maximum size of the pixels of the screen.

24. The system of claim **19**, further comprising a support element with an exterior surface and with a hole for receiving the textured display element and at least a portion of the block, wherein the exterior surface has a texture and wherein the non-planar exterior surface has a texture matching the texture of the exterior surface of the support element.

25. A display system, comprising:

a display device with a monitor having a screen operable to output light associated with still or animated images;

a block comprising a plurality of optical fibers bonded together to define parallel guide paths, wherein first ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface and wherein the first block surface is positioned adjacent the screen to receive and transmit the output light along the guide paths to the second block surface; and

a textured display element covering the second block surface with an interior surface receiving the output light exiting the second block surface and a non-planar exterior surface opposite the interior surface emitting the output light received at the interior surface,

wherein the display device comprises a digital display emitting the output light from pixels of the screen, and

wherein the optical fibers each have a diameter having a magnitude less than a maximum size of the pixels of the screen.

26. The system of claim **25**, wherein the textured display element has a body formed of a substantially transparent material with an index of refraction matching an index of refraction of the optical fibers in the block and wherein the body has a maximum thickness of **1** millimeter and wherein the interior surface is bonded to the second surface of the block without air gaps.

27. The system of claim **25**, wherein the textured display element has a body formed of a substantially transparent material with an index of refraction matching an index of refraction of the optical fibers in the block and wherein the textured display element further comprises a layer of transparent paint covering at least portions of the non-planar exterior surface, whereby the textured display element is substantially opaque to light striking the non-planar exterior surface while concurrently being at least translucent to the output light received at the interior surface.

28. The system of claim **25**, wherein the first and second block surfaces are planar and wherein the first block surface is optically bonded to the screen of the monitor of the display device.

29. The system of claim **25**, wherein the first block surface is planar and placed in abutting contact with the screen of the monitor of the display device and wherein the optical fibers of the blocks are provided with two or more lengths whereby the second block surface is non-planar.

30. The system of claim **25**, further comprising a support element with an exterior surface and with a hole for receiving the textured display element and at least a portion of the block, wherein the exterior surface has a texture and wherein the non-planar exterior surface has a texture matching the texture of the exterior surface of the support element.

31. An optical assembly for use with a digital display device with a planar monitor screen, comprising:

a block of optical fibers, wherein first ends of the optical fibers define a first block surface and second ends of the optical fibers define a second block surface, wherein the first block surface is planar for mating with the planar monitor screen; and

a textured display element comprising a layer of material covering at least the second block surface of the block with an interior surface adjacent the second block surface and exterior surface facing away from the block,

wherein the exterior surface is textured and wherein the material of the layer is substantially transparent to light, and

wherein the material of the layer in the textured display element has an index of refraction matching an index of refraction of the optical fibers.

32. The assembly of claim **31**, wherein the second block surface is non-planar.

33. The assembly of claim **31**, wherein the layer of the material has a thickness less than about 1 millimeter.

34. The assembly of claim **31**, wherein the interior surface of the layer of material is mated to the second surface of the block without air gaps therebetween.

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